RESEARCH HIGHLIGHTS

January 2004

Technical Series 04-105

FIELD TESTING OF AN INTEGRATED VENTILATION SPACE CONDITIONING SYSTEM FOR APARTMENTS

Introduction

Ventilation strategies for apartments have not changed significantly over the past 30 years despite significant evolutions in the design and construction of building envelopes, improvement in heating system efficiencies and the growing awareness—on the part of occupants—of the need for healthy, secure indoor environments. The standard approach to ventilating apartment buildings is to deliver conditioned air to the common corridors of each floor aiming at:

1. pressurizing the corridors to prevent odour proliferation
2. ventilating the corridors
3. providing make-up air for unbalanced exhaust appliances
4. providing fresh air to the occupants within individual apartments

CMHC research, and that of others, has shown that if this strategy succeeds in meeting any of the aforementioned objectives, it occurs more by accident than design (see CMHC *Research Highlight 99-118 Field Testing to Characterize Suite Ventilation in Recently Constructed Mid- and High-Rise Residential Buildings*).

A growing awareness of the failings of conventional approaches to multi-unit building ventilation has prompted leading edge developers to consider alternative strategies not only to improve the indoor environment but also to reduce energy consumption. MintoUrban Communities, working closely with a leading Canadian residential ventilation system manufacturer, recently developed and installed seven prototypes of an integrated ventilation-space conditioning (VSC) system that combines the function and familiarity of vertical fan-coil units with an innovative heat recovery ventilation (HRV) system (Figure 1). In support of MintoUrban Communities leadership role in seeking ways to develop more effective and efficient ventilation systems for apartments, Canada Mortgage and Housing Corporation initiated a research project to evaluate the performance of the prototypes that were installed in a newly constructed apartment building in Toronto, Ontario. The goals of the research project were to:

- assess the performance of the VSC system
- suggest improvements in design
- gain a better appreciation of the working environment in which ventilation systems operate in multi-unit residential buildings

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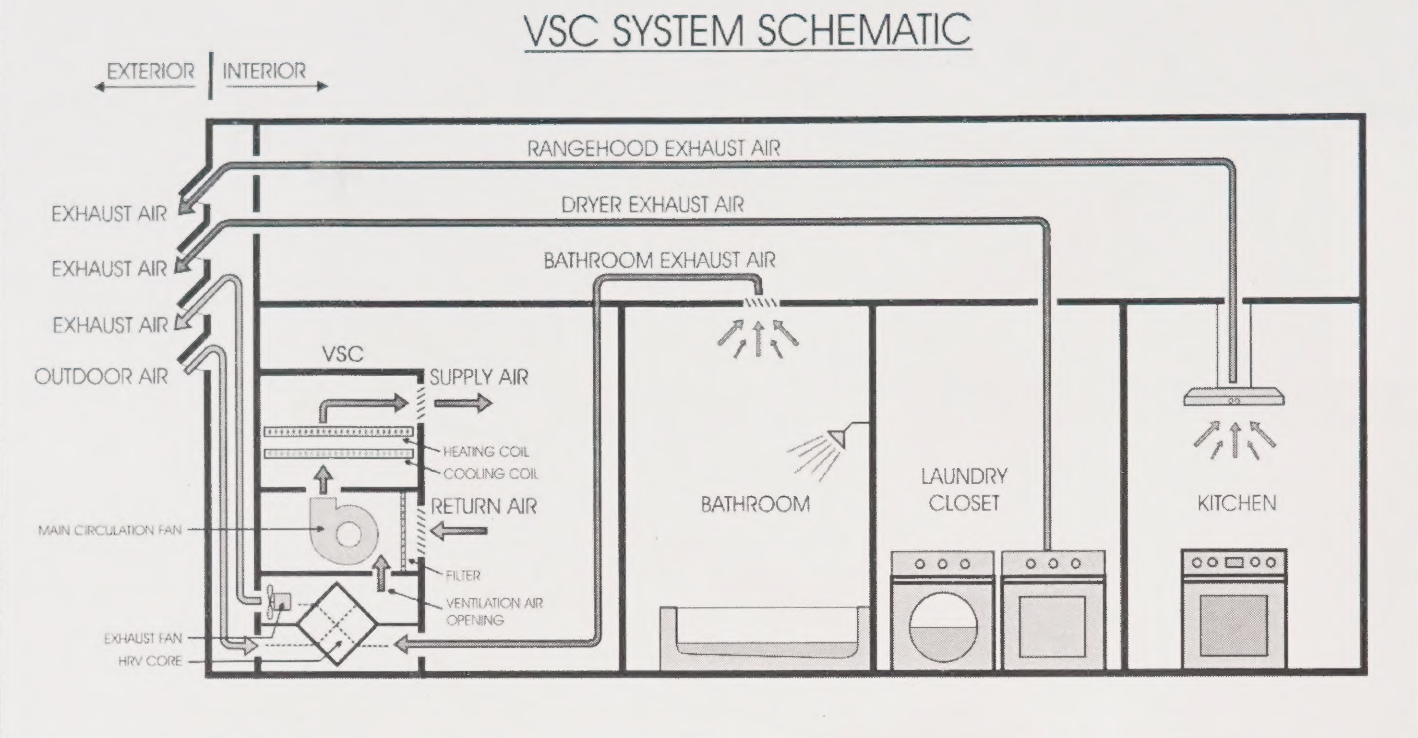
Figure 1: VSC System Schematic



VSC System Description: The VSC system is comprised of a four-pipe vertical fan coil unit with a built-in heat recovery ventilation system. The fan coil heats or cools recirculated air returned from the apartment and supplies it back into the space. Fresh outdoor air is drawn into the return air plenum of the fan coil by the negative pressure developed by the operation of the circulation fan. The fresh air passes through a heat recovery core before it mixes with the return air. Exhaust air is drawn from the bathroom by a fan located in the fan coil cabinet. The exhaust air flows through the heat recovery core and is then vented outdoors. The amount of fresh air drawn into the apartment can be increased by operating the recirculation fan at higher speeds. The exhaust airflow can be increased automatically by a dehumidistat or manually by a wall switch located in the bathroom.

Research Program

A research project was organized to assess the performance of the VSC system and to characterize some of the parameters that may influence its operation. The research, conducted by Enermodal Engineering Limited, included the following tasks:

VSC Airflow Capacity Measurements: The airflow capacity (ventilation, exhaust and room air circulation flows) of the VSC system was measured under a variety of operating conditions. Exhaust airflows from the range hood and clothes dryer were also measured.

VSC Stall Test: A test was conducted to determine the relationship between the suite pressurization and ventilation airflow rate through the VSC. This test provided insight into the ability of the VSC unit to draw in outdoor air when operating against stack and wind pressures.

Suite Air Leakage Characteristics: The air leakage characteristics of the test suites were determined to provide context for the measured performance of the VSC system, its potential impact on adjacent suites and the need for make-up air for unbalanced exhaust appliances.

Characterizing Air Pressure Regimes: This test involved the assessment of the effects of operating various exhaust fans on air pressure within the test suite and the adjacent suites. The results of this test were also used to determine the impact of unbalanced exhaust appliances on VSC ventilation airflow. The results were also assessed to determine whether or not the operation of unbalanced exhaust appliances could adversely affect the venting of combustion appliances that could be potentially installed in apartments.

Characterizing Corridor Air Leakage: This test was undertaken to describe the air leakage characteristics of one of the common corridors. The air leakage area of the corridor and the percentage leakage area that can be attributed to the cracks around the doors to the suites were determined. This test provided information to assess the potential for reducing the capacity of the corridor air supply system in concert with the installation of in-suite ventilation.

VSC Energy Consumption: Measurements of the electrical power requirements for the VSC units, as well as the corridor ventilation fan, were recorded. The expected annual electricity consumption to provide ventilation air through the use of individual suite ventilation appliances versus central ventilation systems was then calculated and compared.

Research Findings

Test Conditions: The VSC performance testing was conducted between May 5-13, 2003. Outdoor temperatures ranged from 8°C to 18°C with wind speeds between 1.6 m/s to 5 m/s. Three VSC installations were tested on the 5th, 8th and 11th storeys of the 18-storey building.

VSC Airflow Capacity: The VSC was designed to provide continuous outdoor ventilation and exhaust airflow rates of 15 L/s (30 cfm) on low speed and 50 L/s (100 cfm) on high speed. Testing showed that the measured outdoor ventilation and exhaust airflows through the VSC system were close to design values when the suite door was unsealed and there was little air pressure difference between the inside of the suite and outdoors.

As expected, the outdoor ventilation airflow and exhaust airflows were found to vary independently of each other, as there is no interlock between the circulation and exhaust fans. The outdoor ventilation flow increased from about 12.5 L/s (25 cfm) to 20 L/s (40 cfm) as the circulation fan speed increased from low to high. The exhaust flow rates, as measured at the bathroom exhaust grille, were found to range between 15 L/s and 30 L/s depending on the exhaust fan setting. Significantly more exhaust flow was measured at the exterior exhaust grille on either setting indicating leakage within the exhaust air stream of the VSC system.

The testing also showed that both the VSC system outdoor ventilation and exhaust airflows could be significantly affected (supply air increased, exhaust air decreased) by the operation of either the range

hood or clothes dryer when the suite corridor door was sealed. Thus, the impact of in-suite exhaust appliances would have to be considered in the design of ventilating appliances such as the VSC system. The VSC system cannot be relied upon as a make-up air device for the kitchen range hood or the dryer, and another source of make-up air would have to be considered.

VSC Stall Test: The VSC system outdoor ventilation airflow could be stalled when indoor pressures were raised to exceed outdoor pressures by 10 Pa to 20 Pa. This indicates that the VSC system is very sensitive to indoor-outdoor pressure differences. Thus the system would benefit from the addition of a dedicated outdoor ventilation supply air fan to ensure balanced and predictable flow through the VSC system under a range of adverse operating conditions.

Suite Air Leakage Characteristics: The suite interior and exterior partitions were found to be extremely tight (0.70 cm^2/m^2 or 1.0 $in^2/100\ ft^2$ @ 10 Pa). Even the partition walls (of the suites where the VSC units were installed) were found to be airtight to the point that a 60 Pa pressure drop induced in one suite had virtually no impact on the adjacent suites. The partition walls in the suites tested were solid concrete shear walls and were not necessarily representative of other partitions in the rest of the building. The test showed that most—if not all—of the air exchange in the suites would be a result of the operation of the VSC system if the corridor door were to be sealed. It also showed that make-up air for the range hood and clothes dryer would have to be purposely supplied, as there was insufficient leakage area available in the suite to meet make-up air needs.

Characterizing Suite Air Pressure Regimes: When the suite corridor door was sealed, it was found that the in-suite exhaust fans could depressurize the suite below 50 Pa. Even the VSC system exhaust fan operating on low speed could produce 10 Pa of negative pressure within the suite. Thus the operation of the in-suite exhaust appliances could produce conditions that would adversely affect the operation of any one of the exhaust fans and could conceivably pose a problem should combustion appliances (for example, wood burning fireplaces, natural gas-fired appliances with unsealed combustion and venting systems) ever be installed in similar suites.

Characterizing Corridor Air Leakage: The corridor air leakage testing found that the suite corridor doors were responsible for 50 per cent of the available leakage area of the corridor. This implied that 50 per cent of the air delivered to the corridors would find other routes out of the building, via elevator shafts, garbage chutes, service conduits, stairwells, etc. rather than flowing to the suites. This finding indicates that were the suite corridor doors to be sealed as part of an in-suite ventilation strategy, there is a potential to significantly downsize the capacity of the corridor air system to save on capital and operating costs.

VSC Energy Consumption: The VSC system was found to draw 193 watts when operating with the circulation fan on the medium setting and the exhaust fan on low. The circulation airflow under these conditions is 229 L/s (458 cfm); therefore, the system uses approximately 0.844 W/L/s (0.422 W/cfm). This is typical of standard motor-fan sets and is comparable with conventional vertical fan-coil units of similar capacity. VSC system fan energy may be reduced by changing the default recirculation fan speed from medium to low, by revisiting the cabinet design and fan selection, and by using a brushless direct current-type motor instead of a Permanent Split Capacitor (PSC) motor.

The use of VSC systems for providing ventilation air directly to the suites could lead to an overall reduction in building fan electricity consumption if the capacity of the central corridor air system were to be downsized. Further evaluation is required to quantify the potential overall fan energy savings

associated with equipping the individual suites within a given building with VSC systems. The heat recovery efficiency of the VSC system was not measured during field testing due to mild weather conditions but is expected to be in the range of 50 per cent to 65 per cent.

Implications for Housing Industry

The development of the integrated ventilation space conditioning system demonstrates that viable alternatives to conventional ventilation systems for multi-unit residential buildings are both possible and practical. However, the project also found that there are many unexplored issues surrounding the design, installation and performance of in-suite ventilation systems in multi-unit buildings that must be addressed before the application of in-suite systems becomes commonplace. With the continued support of the building industry, improved ventilation strategies for apartments will be devised, tested and may eventually become the norm thereby significantly enhancing the quality of the indoor environment, energy efficiency, safety and building envelope durability of multi-unit residential buildings.

A full report on this project is available from the Canadian Housing Information Centre.

Housing Research at CMHC

Under Part IX of the *National Housing Act*, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's research report.

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The Canadian Housing Information Centre
Canada Mortgage and Housing Corporation
700 Montreal Road
Ottawa, ON K1A 0P7
Telephone: (613) 748-2367
Fax: (613) 748-2098
OUR WEB SITE ADDRESS:
http://www.cmch-schl.gc.ca/Research

Project Manager: Duncan Hill

Research Consultant: Enermodal Engineering Limited

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www.cmhc.ca

or contact:

Canada Mortgage and Housing Corporation
700 Montreal Road
Ottawa, Ontario
K1A 0P7

Phone: 1 800 668-2642
Fax: 1 800 245-9274

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